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Formation of magnetic moments in the cuprate superconductor $Hg_{0.8}Cu_{0.2}Ba_2Ca_2Cu_3O_{8+\delta}$ below T_c seen by NQR

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Abstract

We report pure zero field nuclear magnetic resonance (NQR) measurements on the optimally doped three layer high-T_c-compounds HgBaCaCuO and HgBaCaCuO(F) with $T_c = 134$ K. Above T_c two Cu NQR line pairs are observed in the spectra corresponding to the two inequivalent Cu lattice sites. Below T_c the Cu NQR spectra show additional lines leading to the extreme broadened Cu NQR spectra at 4.2 K well known for the HgBaCaCuO compounds. The spin–lattice relaxation curves follow a triple exponential function with coefficients depend onto the saturation time (number of saturation pulses), whereas the spin–spin relaxation curve is described by a single exponential function. From the spin–lattice relaxation we deduced a complete removal of the Kramers degeneracy of the Cu quadrupole levels indicating that the additional lines are due to a Zeemann splitting of the $^{63/65}$Cu lines due to the spontaneous formation of magnetic moments within the CuO layers. Below 140 K, the spectra are well fitted by a number of 6 $^{63/65}$Cu line pairs. From the number of the Cu lines, the position of the lines relative to each other and the complete removal of the Kramers degeneracy we deduced an orientation of the magnetic moments parallel to the c-axis with magnitudes of the order of 1000 G. We also discuss the possible microscopic origin of the observed internal magnetic fields.
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1. Introduction

A possible co-existence of antiferromagnetism and superconductivity remains one of the most interesting problem in high-T_c cuprates. Despite that in several theoretical scenarios of high-T_c superconductivity in cuprates the Cooper-pairing arises due to an exchange of antiferromagnetic spin fluctuations present in the paramagnetic phase [1,2], it is commonly believed that bulk superconductivity and the antiferromagnetism do not co-exist in the cuprates at the same doping concentration and temperature. However, recently possible formation of antiferromagnetism below the superconducting transition temperature was found by several experimental techniques in underdoped $YBa_2Cu_3O_x$ and $La_{2-x}Sr_xCuO_4$ [3–6].

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